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MINING METHODS AND PRACTICES, POTASH CO. OF AMERICA, EDDY COUNTY, N. MEX.

BY

WALTER R. STORMS

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MINING METHODS AND PRACTICES, POTASH CO. OF AMERICA, EDDY COUNTY, N. MEX.[1]

By Walter R. Storms[2]

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7445."

[2] Senior mining engineer, Bureau of Mines.

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INTRODUCTION

This paper, which describes the mining methods of the Potash Co. of America in Eddy County, N. Mex., is one of a series being prepared by the Mining Branch of the Bureau of Mines on mining practices and methods in various mining districts of the United States.

The mine and plant of Potash Co. of America are situated in sec. 4, T. 20 S., R. 30 E., N. M. P. M., about 22 miles by paved road northeast of Carlsbad (fig. 1). A spur line of the Atchison, Topeka & Santa Fe Railroad also connects the mine with Carlsbad.

ACKNOWLEDGMENTS

Acknowledgment is made to the executives and staff of Potash Co. of America for permission to publish this paper and for their valuable help. Special acknowledgment is due G. F. Coope, president; P. S. Dunn, resident manager; R. M. Magraw, formerly general manager until his recent retirement and now mining consultant; R. A. Pierce, formerly assistant general manager and now consulting engineer; and L. D. Anderson, consulting engineer. Special acknowledgment also is due Russell Haworth, assistant resident manager, who wrote several sections of this report, furnished maps and photographs, and was very helpful in many other ways.

HISTORY

In 1911 Congress made its first appropriation available for potash research to the Bureau of Soils and the Federal Geological Survey. Although funds were limited many possible sources of potash, including brines and saline deposits, were investigated. In 1912 J. A. Udden of the University of Texas discovered potash salts in well bailings in the Permian Basin in Dickens County, Tex. Finally in 1926 the Bureau of Mines and the Federal Geological Survey obtained an appropriation to core drill the salt strata of the Permian Basin in New Mexico and Texas. Meanwhile in 1925 the Snowden & McSweeney Co. had found crystals of the potash mineral, sylvite, in oil-well bailings near Carlsbad, N. Mex. This latter discovery, with the work by the Government bureaus, led to establishment of the present potash industry near that city.

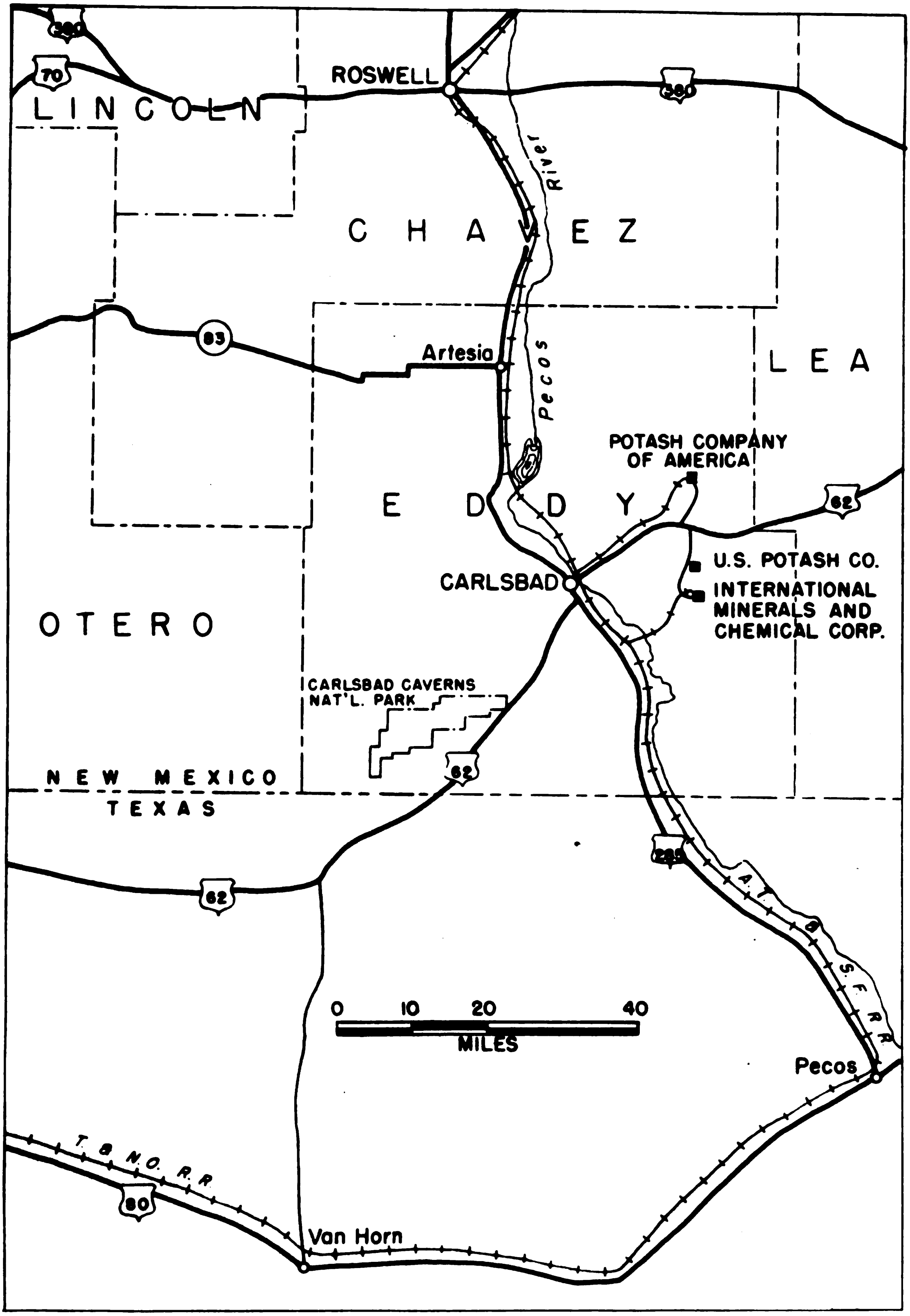

Figure I. - Potash mines in Eddy County, N. Mex.

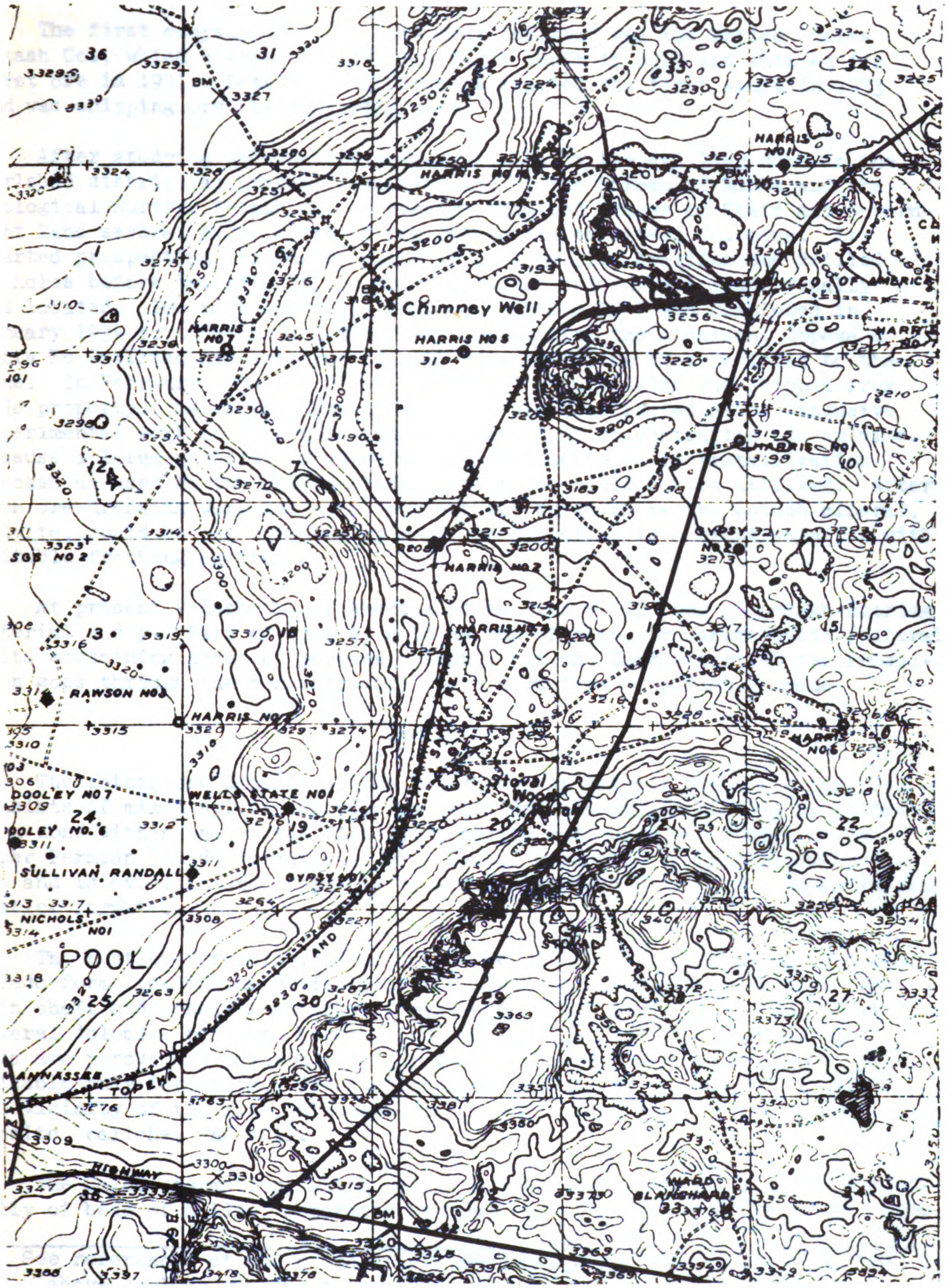

Figure 2. - Topographic map, Potash Co. of America.

The first company to start work near Carlsbad was the United States Potash Co., which started to sink its first shaft in 1929 and shipped its first ore in 1931. Potash Co. of America started its first shaft in 1933 and was shipping ore the following year.

After studying information made available by the drilling done in the Carlsbad district by private companies and by the Bureau of Mines and the Geological Survey, Potash Co. of America obtained leases on State and Government land several miles north of the United States Potash Co. mine. It started prospecting its leases early in 1931 by core drilling and drilled 20 holes before the site of the original shaft and surface plant finally was located. The main shaft was started in March 1933 and completed in January 1934 to a depth of 1,085 feet. Meanwhile, the Atchison, Topeka & Santa Fe Railroad had constructed a 22-mile spur line from Carlsbad to the mine. In February 1934 the first carload of manure salts was shipped from this property. Later the present refinery was constructed after extensive experimental work to determine the best method of concentrating the sylvite. Because a large quantity of water was not available, a recyrstallization process as used by the United States Potash Co. could not be utilized. After much ore-dressing work was done, a plant was built where the potash mineral, sylvite, could be concentrated by means of flotation in a brine solution with suitable frothing agents.

At present Potash Co. of America mines over 3,000 tons of potash-bearing material a day. Part of this is sold as run-of-mine, or manure salts (natural salts containing about 25 percent potash), but the larger part of the production goes through the concentrator, where a muriate of potash is made.

GEOLOGY[3]

The potash ore deposit at the Potash Co. of America mine (see fig. 2) consists of mixed sylvite (potassium chloride) and halite (sodium chloride) in a zone within one of the flat-lying halite beds near the middle of the Upper Permian Salado formation. This Salado formation is predominantly halite and is overlain unconformably by several hundred feet of the Upper Permian Rustler formation.

The Rustler formation, of late Permian age, lies unconformably upon the Salado formation in the vicinity of the mine. It is 422 feet thick at the main shaft and consists chiefly of gypsum and "Red Beds," but also contains several dolomite beds and several beds of sand and gravel. Some dolomite beds are porous and contain considerable water, but this water usually is suitable only for stock. The Rustler formation forms the country rock in the vicinity of the mine, although it is almost entirely covered by sand, gypsite, caliche, and soil.

The Salado formation, which occurs beneath the Rustler, consists principally of beds of halite, separated by bands of anhydrite and polyhalite, some halite beds being over 100 feet thick while the anhydrite and polyhalite are only from a few inches to a few feet. The maximum thickness of the formation in this area is about 1,600 feet. There are about 45 persistent sulfate, and as many halite beds. The potash deposits lie near the middle of the formation as originally laid down and about 990 feet below the surface. Through a thickness of about 150 feet are thin zones rich in potash-bearing minerals, principally sylvite. Only one sylvite-bearing bed is being mined in the Carlsbad district at present (this bed is called the "28" bed by the Federal Geological Survey and the "N" bed by Potash Co. of America), although one bed, which carries langbeinite about 100 feet above the 28-bed, is being worked by one company. The other potash-bearing beds are too thin, not sufficiently rich, or too small in areal extent for exploitation at present.

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[3] See references at end of paper for more detailed geology. Much of the above geology was taken from a report on the general area near the Potash Co. of America mine by Ralph H. King of the Geological Survey.

In the vicinity of Potash Co. of America, sylvite has been deposited in a considerable area and in a zone several feet thick, along with the halite of the Salado formation, in amounts sufficient to constitute ore. In most parts of the deposit the change from ore to barren salt above and below is fairly abrupt, but the lateral transition at the edges of the ore body is gradual. Barren masses of halite, known as "salt horses", are scattered irregularly throughout the ore body.

The ore is an intimate intergrowth of crystalline halite and sylvite in various proportions. Most of the ore contains about half as much sylvite as halite. The grains or cyrstals range from specks to masses 6 inches across. However, most of them are only 1/4- to 3/4-inch in diameter. Stringers and disseminations of clay also are found in the ore.

The sylvite commonly is milky or faintly bluish gray, but many grains are stained red by iron oxide. The halite commonly is clear, grayish, or buff or orange-yellow, but it also may be stained red by iron oxides. Blue halite sometimes is found associated with the sylvite.

The 28-bed at Potash Co. of America averages about 6 feet where mined, although some ore has been extracted as a conservation measure where the bed was somewhat thinner. It dips gently to the east, although minor folds occur, sometimes with dips up to several percent.

METHODS OF PROSPECTING AND EXPLORATION

Potash Co. of America began exploratory work by core drilling on its leased State and Government land early in 1931 and by January 1933 had completed 31 holes. Development of the property then was begun, but many more drill holes have since been put down to further outline the ore body.

R. A. Pierce and L. D. Anderson have described this early drilling program as follows:4/

4/ Pierce, R. A. and Anderson, L. D., Potash Company of America - Producer of Sylvite at Carlsbad: Eng. and Min. Jour., vol. 142, No. 12, December 1941, pp. 37-41.

For prospecting, the company contracted the services of two drilling companies, both of which had just been released from Government tests and were familiar with the coring of highly soluble potash salts. Locations for testing, depths to be drilled, character of drilling solutions, receiving and examinations, and analyses of cores were handled by the compnay's staff.

In drilling the sedimentary "Red Beds" or "Rustler" formation that covers the Salado halite the customary procedure is to use cable tools until the halite is reached, as it is much cheaper than core drilling, and the information desired, such as water horizons, and character of rock, can be determined with sufficient accuracy thus.

After landing on the halite bed with not less than 5-3/16-inch casing, and before core drilling is started, a seal is made between the casing and the hole. The seal is made to eliminate the possibility of water entering the hole while core-drilling in the halite and to prevent the loss of drilling solution through the overburden during the process of forcing the salt cuttings to the surface, where they are settled out before the brine is recirculated. The drilling solution used at first was a saturated solution of sodium chloride, magnesium chloride, and potassium chloride. Later, when it became available, carnallite or sylvinite was substituted for the salts. With a saturated solution no leaching appears on the cores and an accurate determination of the mineralization can be made.

A double core barrel 16 feet long is used. The size of core cut is 2½ inches in diameter and runs of 15 feet can usually be made before lifting. The cutting bit is slightly different from the one ordinarily used where the drilling fluid passes over the core and inner portion of the bit before returning across the face. With a salt bit the walls are double and the solution, instead of washing the core, is forced out through the face of the bit, which eliminates all contact between the solution and the core while cutting. Erosion is also eliminated thus. Diamonds are used for cutting and in most cases the recovery of full sized cores closely approaches 100 percent.

Potash Co. of America uses a coordinate system for spacing its surface drill holes, with holes drilled vertically at regular intervals. All holes are drilled to end well below the 28-bed. All leased areas are drilled well in advance of underground development work so continuity and thickness of ore are known before development and mining are begun. However, barren "salt horses" occur irregularly through the deposit, and these cannot be located in advance with any certainty.

Recently the company has done some exploratory work underground by diamond-drill holes drilled from development faces. These holes are especially helpful in planning development work where "salt horses" and folds are encountered in the sylvite bed.

METHODS OF SAMPLING AND ESTIMATING TONNAGES AND VALUES

Two types of samples are taken underground. Drill cuttings from each development and extraction face are used in sampling the ore body. Grab samples are taken from fines in each car and serve to indicate the source of any excessive dilution.

From 16 to 30 holes are drilled in each standard round in entries and rooms. The cuttings from the holes are rather fine and normally collect in conical heaps on the smooth floor formed by the undercutting operation. A grab sample from the left, center, and right row of drill-hole cuttings is made, care being taken to get a representative section of the cone. Cuttings from the last feet of drilling seldom are included, since the hole is not cleaned perfectly with the auger-type drill steel. In top holes this last foot is drilled in most cases above the ore in salt. The grab sample represents ore in place. Dilution, consisting of overbreak above the ore and waste cuttings from the undercutting machine, is not represented in this sample. Thickness of the bed as represented by the sample is measured at each rib and at the center of the face and recorded on a sample card. Included on the card is a measurement from the nearest numbered survey station. The card is included with the sample when it is sent to the laboratory for analysis. Samples are averaged for every 100 feet and recorded on sample maps with the average thickness of the ore. The resulting data are used for computation of pillar, or developed ore reserves. The grade of the ore is reasonably uniform and a visual examination by an experienced miner or foreman is sufficient for determination of ore or of waste.

Grab samples are taken from the fines in each car and separated according to operating sections in the mine. These samples indicate the source of excessive dilution.

Occasional channel samples are taken to check various portions of the bed. The transition zone from ore to salt is normally sharp and distinct, thus making channel samples for mine control unnecessary.

Ore reserves can be calculated readily in the developed sections of the mine from data compiled from the samples of drill cuttings. Developed reserves and pillar reserves are compiled and totaled monthly. Ore removed from reserves is calculated and deducted similarly. Indicated ore reserves are calculated from surface drill hole data.

DEVELOPMENT METHODS

Shafts

No. 1 shaft, completed in 1934, was sunk to a depth of 1,085 feet through 422 feet of overlying sand, shales, and limestone beds, and 663 feet of salt formation. The potash-bearing 28-bed was struck at 994 feet. The shaft contains three compartments, each 5 feet by 6 feet 4 inches in the clear. It is concreted from the surface to the 430-foot point. Two compartments are used for hoisting ore, supplies, and men, while the third is used for a manway and

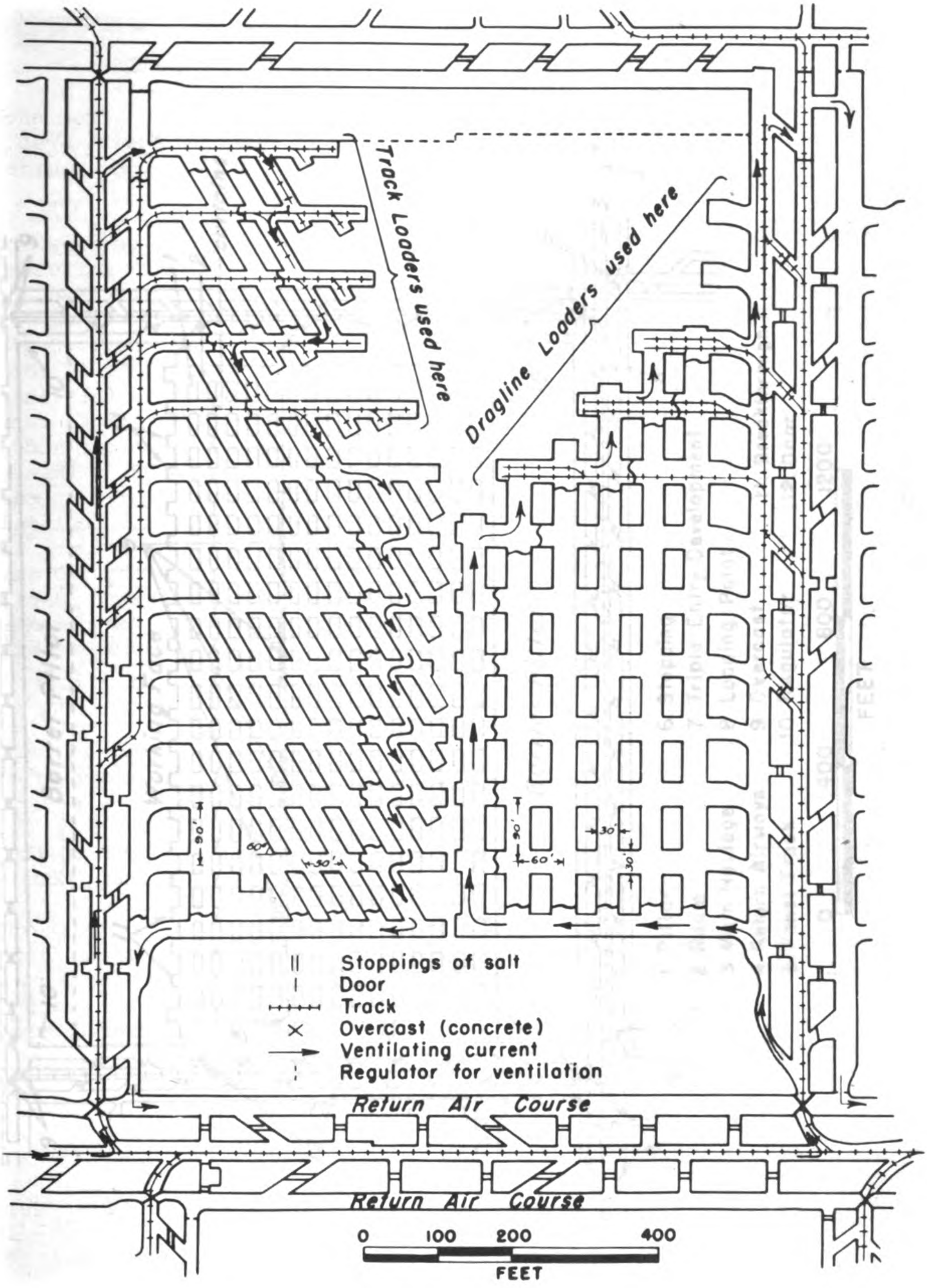

Figure 3. - Initial development and mining methods, Potash Co. of America.

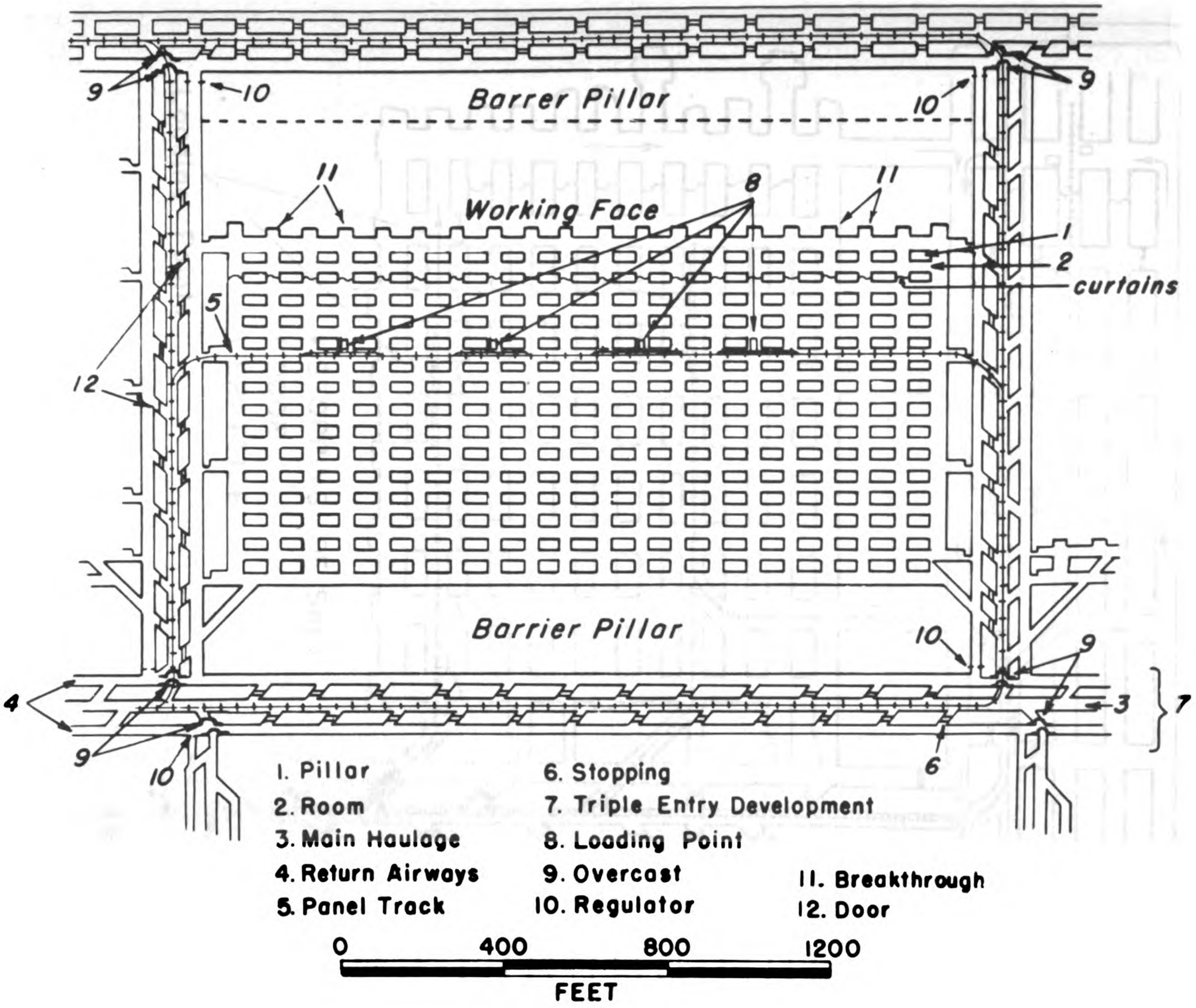

Figure 4. - Recent development and mining methods, Potash Co. of America.

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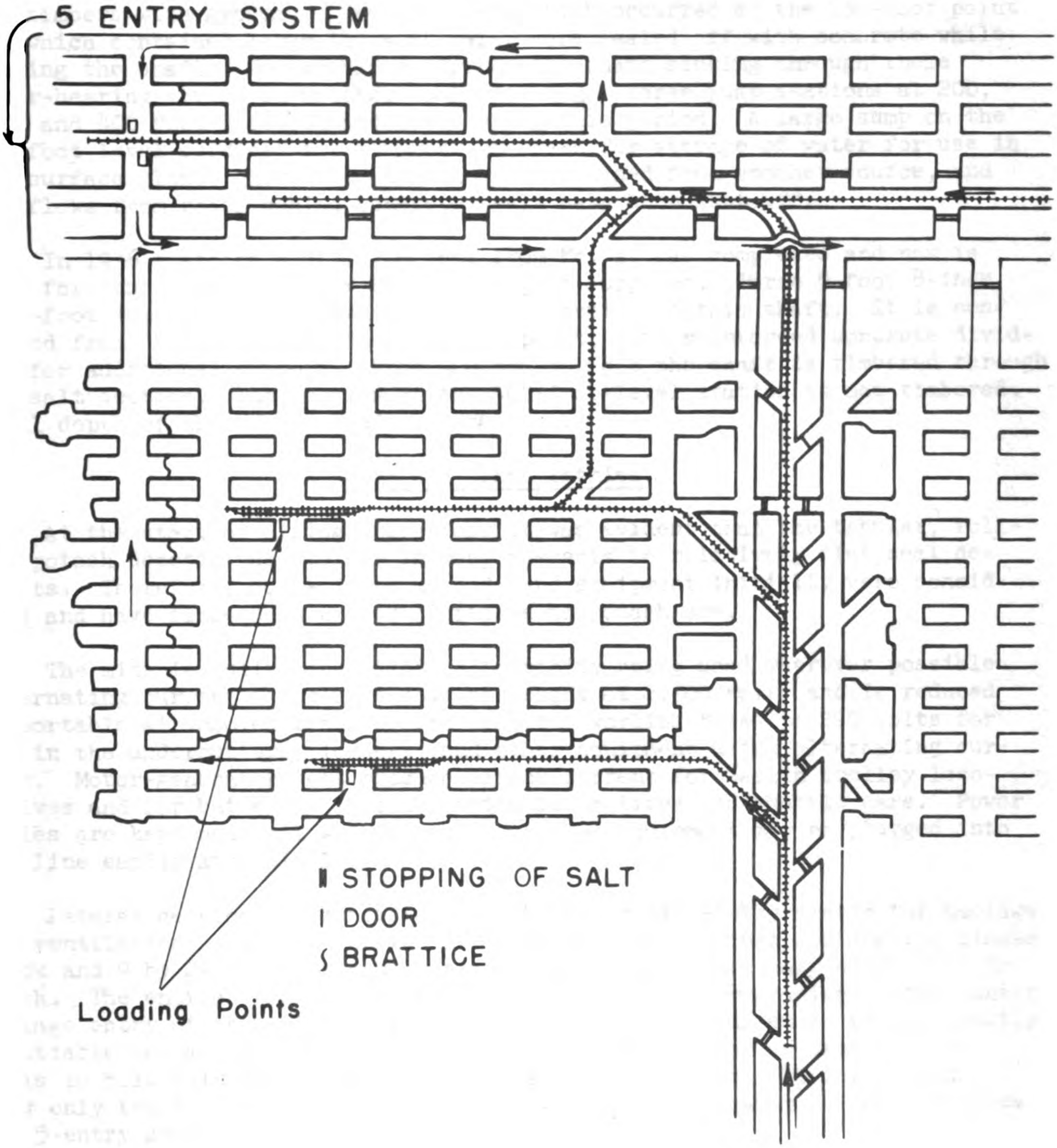

Figure 5. - Five-entry system.

for various pipe and power lines. The shaft is timbered throughout with 10- by 10-inch wall and end plates and 8- by 10-inch dividers. Posts are 10- by 10-inch by 5 feet. The timbers were not treated. Seepage from the beds in the upper portion of the shaft, with a high rate of evaporation, has coated all timbers with gypsum. Limestone beds which occurred at the 255-foot point and which contained large flows of water were sealed off with concrete while sinking the shaft. Magraw has described the shaft sinking through these water-bearing strata in another publication.[5] Three pump stations at 200, 300, and 400 feet were cut and used during this period. A large sump on the 200-foot level sufficed for a number of years for storage of water for use in the surface plant. However, water now is obtained from another source, and all flows from zones behind concrete seals have been shut off.

In 1936 a second shaft, 700 feet from No. 1, was completed and now is used for ventilation and for the handling of supplies. Three 5-foot 8-inch by 5-foot compartments comprise the cross section of this shaft. It is concreted from the surface to the 420-foot point, with reinforced concrete dividers for additional support. From 420 to 950 feet the shaft is timbered through the salt section. The section at the 900-foot-level station is not timbered. Total depth of this No. 2 shaft is 986 feet.

Main and Cross Entries

At the start of mining operations it was evident that the tabular, rolling potash deposit was similar in many respects to relatively flat coal deposits. Therefore, coal-mining methods and equipment initially were considered and have since been proved adaptable to potash ore.

The mine is fully mechanized, electricity being used wherever possible. Alternating current is brought down the shaft at 2,300 volts and is reduced by portable air-cooled transformers near the working faces to 220 volts for use in the undercutters, loaders, and other equipment using alternating current. Motor-generator sets produce direct current for use in trolley locomotives and for batteries in combination locomotives and shuttle cars. Power cables are kept near all working faces so that equipment may be plugged into the line easily and quickly.

Lateral development consists of a three- or five-entry system for haulage and ventilation. Haulage entries are 9 by 14 feet in cross section for single track and 9 by 24 feet for double track. Air courses are carried 24 feet in width. The entries are driven on the ore horizon, and regrading of the center haulage entry of the triple-entry system usually is required to produce easily negotiable haulage grades. Tunnels have been driven over or under severe rolls to hold main haulage grades to less than 3 percent. Figures 3 and 4 show only triple entries, as this system was used originally. Figure 5 shows the 5-entry system.

On each side of main entries 250-foot barrier pillars are left for protection. Smaller chain pillars are provided between cross entries and panels (fig. 4).

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[5] Magraw, R. M., New Mexico Sylvinite: Ind. Eng. Chem., vol. 30, No. 8, August 1938, pp. 861-864.

The operational cycle consists of undercutting to a depth of 9 feet, drilling to the same depth, track extension where track-mounted machines are used, blasting, and mechanical loading of broken material. At present (early in 1947) some development work is done with the aid of track-mounted loading machines and a Universal-type undercutter. The balance employs "trackless" mining equipment, consisting of caterpillar-mounted loading machines and rubber-tired, battery-powered shuttle cars. The various mining operations of undercutting, drilling, blasting, and loading are virtually identical in both development and extraction.

Most of the main-entry development now is done with trackless mining equipment on a five-entry system (fig. 5), although original development was with triple entries. Light track is extended in one of the air courses, and elevating conveyors or ramps are installed within 300 to 400 feet of the entry face. The ore is loaded into shuttle cars, which haul the material to one of these discharge points and discharge it into mine cars. Combination battery and trolley locomotives, operating on battery over the light temporary track, haul the loaded cars to the closest siding where the main-line trolley locomotive can pick up the loaded cars. Placing temporary track in an aircourse allows operations to proceed along the contour of the ore body to a point between 1,000 and 2,000 feet beyond the end of the graded haulage entry.

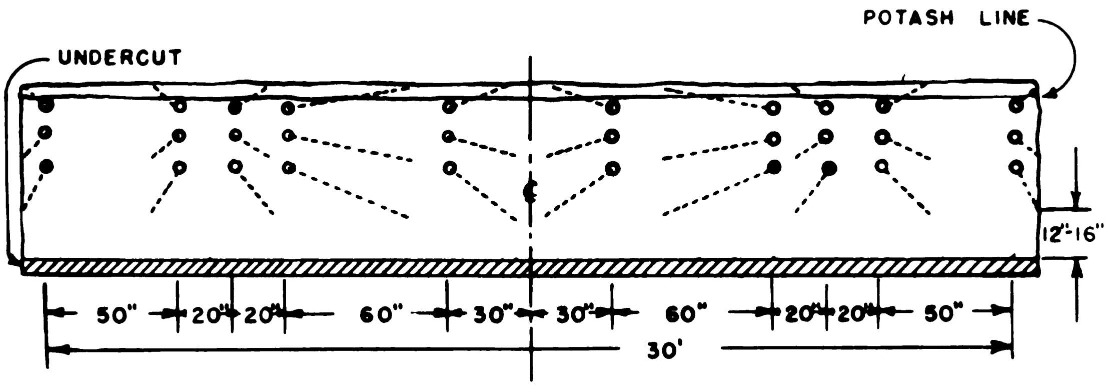
The optimum haulage grade is determined from profiles of the haulage entry. This entry then is brushed and graded, usually in 1,000-foot sections, without interruption to the driving of the entries at the face. Heavy rails, sidings, and trolley lines are extended, and the temporary track then is connected to and extended from the end of this track for another similar cycle. The temporary track adjacent to the new grading is removed, and the materials are used for extending the track at the face.

The five entries thus afford one opening for main haulage and fresh air, two return aircourses, and two entries for storage of waste salt removed from grading operations. Salt often is loaded into shuttle cars which discharge at another loading machine in one of the salt-storage entries. This machine stacks the salt to the roof. This additional operation is required only when the amount of salt from grading is excessive. Normally the shuttle cars discharge the salt in heaps 2 to 3 feet in height.

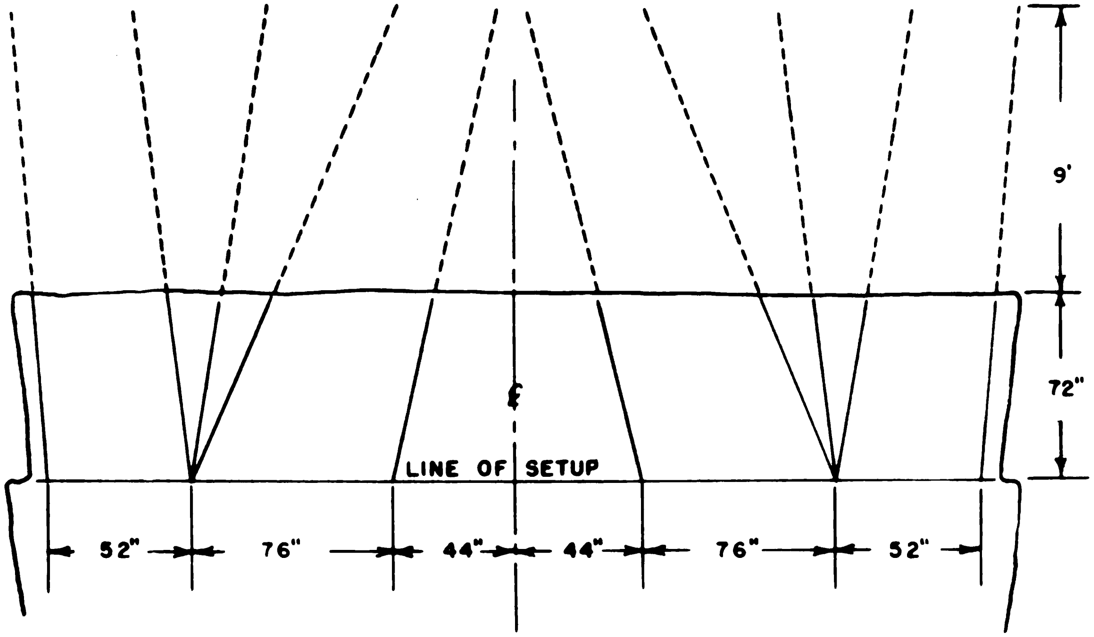
Plans for cross entries are similar, except that three entries are driven in conjunction with four or five rooms adjacent to the chain pillars which protect the entries on each side.

All main- and cross-haulage entries are brushed where necessary to a minimum height of 8 feet above the rail. A clay parting, or seam, occurs at approximately this height, and the salt always is removed up to this parting to eliminate any loose slabs that might result if this procedure were not followed.

Track-mounted equipment is used where tunnels under or over the ore are required in the main haulage entry to alter the grade.



ROOM FACE



ROOM PLAN

FACE WIDTH	SPACING ON FACE FOR HOLES-IN	SPACING ON BACK FOR POST-IN	NO OF HOLES
R 30	50-20-20-60-30-℄-30-60-20-20-50	52-76-44-℄-44-76-52	30
R 28	40-20-20-58-30-℄-30-58-20-20-40	44-72-44-℄-44-72-44	30
E 22	32-20-50-30-℄-30-50-20-32	20-60-44-℄-44-60-20	24

R= ROOM E= ENTRY

Figure 6. - Standard three-row drilling round.

Drilling and Blasting

During the initial period of development from No. 1 shaft, it was found that the somewhat elastic crystalline intergrowth of the salt formation was expensive to break. Fragmentation, even though the material was soft, was not good. Rounds did not break properly, and the cost of explosives was inordinately high. Short-wall undercutting machines were introduced to provide another free face. A 6- to 7-foot undercut was made along the lower contact of the ore, and a toe cut was used to break to this opening. Drilling and blasting costs, including the cost of undercutting, were reduced to a point considerably below that of the initial costs for breaking. In 1939 improved methods were introduced, and a 9-foot cutter bar proved successful, increasing the length of the rounds from 6½ to 8½ feet. Further improvements were made at approximately the same period by combining a horizontal V-cut with the vertical toe cut (fig. 6). This method of drilling threw the ore farther from the face, prevented packing of the blasted material at the face, and resulted in a reduction of dynamite used, as well as in the number of holes required.

Since the composition of the material mined is so uniform, it was possible to install standard methods of drilling and blasting, requiring a minimum of skill on the part of the driller as compared with most mining operations. The driller first marks the center line of the face by sighting plumb lines hung from survey spads set at 100- to 400-foot intervals. The sides then are marked by measuring from this center line, and each row of holes is marked on the face by standard measurements from the center line. The drill posts are set up along a line a prescribed distance from the face, at points also measured and marked on the back. If done carefully, this method insures the proper horizontal angles on the V-cut, and the experience of the driller must be exercised only for the proper vertical angle of the holes (see fig. 6).

Drillers work in pairs, one man working on each side of the face. A row of holes is drilled from the first set-up for the V-cut. One, two, or three vertical rows of holes are drilled from the second, depending on the width of the face, and a third row is drilled on the rib or pillar. Standard face widths are 14 and 22 (or 24) feet for development entries and 30 feet for most rooms in extraction areas. Six rows of holes are drilled in the 14-foot faces, 8 rows in the 22-foot face, and 10 rows in the 30-foot faces. Overbreak horizontally ranges from 6 inches to 1 foot on the points of the holes. Horizontal spacing of the holes at the points is from 40 to 50 inches. Within this range, the results are satisfactory.

Compressed-air equipment for drilling originally was used but soon was abandoned in favor of the post-mounted, 1½-hp. electric auger coal drill. These are handled more easily and drill rapidly in the relatively soft material. Drill speed is 28 inches per minute. Four-and-one-half-, 7- and 11-foot auger steels are used to drill a 9-foot hole. A mole-foot, alloy-steel, detachable bit was used for a number of years but is being replaced with tungsten carbide-tipped, forged bits which require much less frequent sharpening. Both types are sharpened by grinding.

Standard loading and firing order of the holes is practiced as a result of the uniform drilling pattern. All holes are fired by electric primers.

A main blasting switch, locked in a grounded position, is installed in each development or extraction section. Main blasting leads are extended from this switch through the section. A small blasting switch is connected to this line at each entry or room, and a secondary line is extended to a point near the face. All blasting lines are strung on insulators on the roof. Each half of the face is connected in series and these two circuits then connected in parallel with the end of the secondary circuit immediately prior to blasting. If loaded earlier in the shift, the lead wires are shunted until ready to blast. The secondary switches are closed, and the main switch is thrown only after everyone has been checked out of the area. The main switch is connected to the 220-volt circuit. A relatively bulky 65-percent-strength dynamite is used for all purposes.

MINING METHODS

Mining

The original room-and-pillar method of mining has proved quite successful. Pillars are left to provide support for the roof, as subsidence might conceivably create fractures extending upward into overlying water-bearing strata. The width of panels has been increased from approximately 600 feet to 1,800 feet. Barrier pillars 250 feet wide are left on each side between panels and main (north-south) entries, and chain pillars, 68 feet or more in width, between panel and cross (east-west) entries. Present panels are 1,800 by 1,100 feet between these heavy pillars. Room pillars are 22 by 60 feet, 30 by 60 feet, or 37 by 37 feet (see fig. 7).

Widths of rooms and break-throughs range from 24 to 30 feet, depending on roof conditions, and pillar dimensions are adjusted accordingly to provide the proper extraction ratio. Usual room and break-through widths are 30 feet. The 22- by 60-foot pillar is the most widely used. The panel is laid out with the longitudinal axis at right angles to the direction of advance of the panel faces, usually parallel to main entries. Rooms advance the long way of the panel or at right angles to cross entries. Break-throughs are normal to main entries. Thus, while advancing the break-throughs approximately 52 feet from one room center to the next, the rooms themselves can be driven 30 feet from each break-through to connect at the center of the pillar (fig. 7). This system provides three faces in close proximity for the first 30 feet of asvance and one face thereafter. Moving time from face to face for caterpillar-mounted equipment is thus reduced. Twenty-two feet is considered the minimum safe width for pillars. Pillars less than 18 feet in width develop transverse fractures. Survey lines must be kept up to prevent deviation from center lines and consequent weakening of the pillars.

Timber seldom is used. Occasional light stulls are placed in the vicinity of some car-loading points where the roof is blasted out to provide clearance for elevating conveyors.

The operational cycle is almost identical with that described under Development Methods. The face is undercut, drilled, and blasted, and the ore then is loaded into shuttle cars, which transport it to the closest car-loading station. Faces can be drilled before being cut, but drillers cannot properly

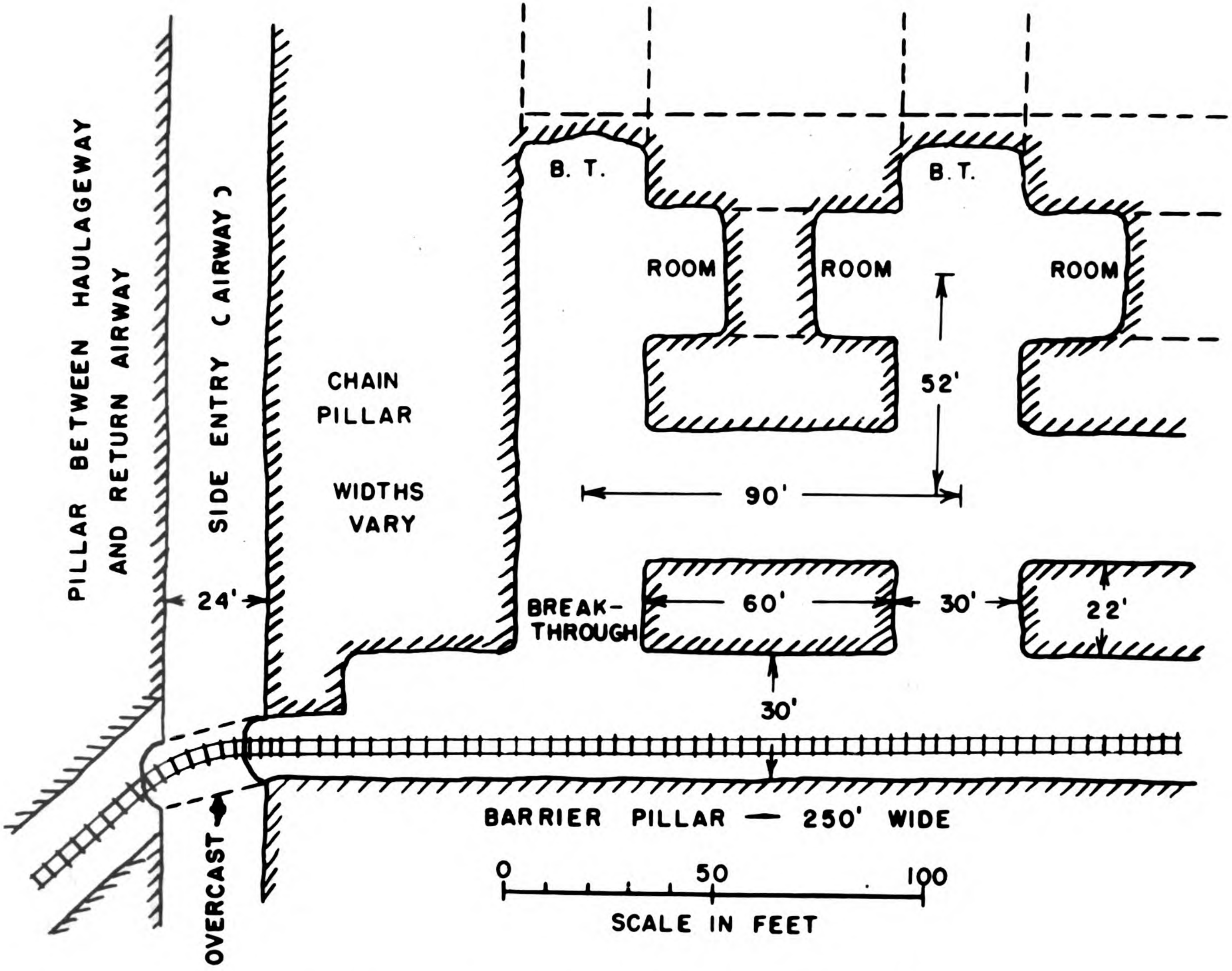


Figure 7. - Sketch showing start of mining in panel.

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gage their bottom holes until the undercut is completed. Component operations of this cycle are described in the next two sections except for drilling and blasting, which are essentially the same as discussed under Development Methods.

A list of equipment as used in each mining unit in 1944 is as follows:[6]

1 loading machine, mounted on caterpillar treads
2 shuttle cars, rubber-tired, battery-powered
2 battery chargers
3 elevating conveyors
2 mining-machine trucks, caterpillar treads
2 undercutting machines
4 post-mounted electric drills
8 electric blower fans
2 2,300 to 220-volt air-cooled portable transformers
2 combination trolley-battery locomotives
Mine cars.

The crew in this mining unit consists of:[7]

1 face boss
1 loader operator and helper
2 shuttle-car operators
2 motormen and helpers
2 undercutter operators and helpers
4 drillers
1 mechanic-electrician
1 shot firer.

Average production for a unit was about 600 tons for an 8-hour shift in 1944.

Undercutting

Shortwall, undercutting machines with 9-foot cutter-bars and 50-hp. motors are used in all sections. Some rubber-tired, Universal-type machines also have recently been placed in service. These are similarly equipped with 9-foot cutter bars and 50 hp. motors. A tungsten carbide-tipped bit now is used in all sections. Cutting speed averages approximately 7 inches a minute. The shortwall machines are moved from one face to another on a caterpillar-type truck with a trailing cable. While operating, the shorter undercutter cable is plugged into an outlet on the truck. The crew consists of an operator and a helper.

The cut is made in the salt immediately below the lower contact of the ore with the salt. This insures recovery of all the ore. The lower contact is quite sharp and fairly regular. Tests have been made with shear or

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[6] Haworth, Russell G., Potash Co. of America Uses Battery Shuttle Cars: Eng. and Min. Jour., vol. 145, No. 5, May 1944, pp. 65-67.
[7] Haworth, Russell B.; see footnote 6.

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vertical cuts by the Universal-type machine. Results were not satisfactory, as more boulders were produced. A minimum amount of dynamite is required for good fragmentation. The undercut is sufficient relief for the round to brea to a depth of 8 feet. One major advantage of the undercut is the resultant smooth floor, which is easy to clean up with mobile loading machines and over which the shuttle cars can travel easily. Small ridges occur at each n cut but do not interfere greatly with loading or haulage.

Loading and Haulage

Loading machines are the caterpillar-mounted type with 50-hp. alternatin current motors and trailing cables. These machines load into shuttle cars, two to three of which are used to transport the ore to a convenient loading point. Some lower direct-current loading machines of the same type are used in the marginal sections of the ore body, where the thickness of the ore is not great. Shuttle-car discharge points consist of either elevating conveyor or ramps. Tracks are laid in every sixth room at approximately 300-foot inte vals, parallel to the panel face and normal to side entries. Shuttle car hau age varies from 100 to 500 feet. Where panel faces are 1,800 feet long, five loading points at 300-foot intervals are employed. Operations start on one end of this panel face and progress to the other and then reverse. Panels ar laid out so that work progresses up the pitch of the beds; this provides a grade in favor of the loaded shuttle cars. Contour maps made from data on elevations taken from surface core-drill holes and from existing workings are used for laying out development work for panels.

Thirty-pound rail is used for the temporary room tracks, and two combina tion trolley and battery locomotives are employed for spotting and gathering cars. No trolley lines are placed in the panels, except on occasional, unavoidable steep grades. Batteries are placed on charge while the locomotives are operating in the cross entries where trips are made up for the main line trolley locomotives. Locomotive haulage also is planned, insofar as possible with favorable grades for loaded trips. Otherwise the batteries will not fur nish sufficient power for operation up to 1,800 feet from a trolley line. The batteries are changed only infrequently, and then for repairs, charging being done while operating on trolley. Locomotives alternate on spotting and gathe ing service during the shift.

Panel repair shops are moved up near the face at approximately 600-foot intervals. Facilities for most repairs are provided. Repairs requiring complete disassembly of loading machines or shuttle cars are made in the main underground shop near No. 1 shaft, where cranes are available.

TRANSPORTATION

All ore is transported from the cross entries to the shaft by trains. Track gage is 42 inches with 52- or 60-pound rails in main entries and 30-pound rails in side entries and rooms (52-pound rails are being replaced by 60-pound ones, and all new main entry track consists of the heavier rails).

Three types of electric locomotive are used - straight trolley, trolley with cable reel, and combination trolley and storage battery. Trolley

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locomotives are used in main and side entries to haul ore to the shaft. Formerly 15-ton trolley locomotives were used, but these are being replaced by 30-ton tandem locomotives. Combination locomotives and the trolley and reel ones are used for spotting and gathering cars in rooms and development work.

Cars with over 100 cubic feet capacity are used throughout the mine. Bodies of these cars are made of copper-bearing steel in rectangular box types. Formerly each car had a 100 cubic feet capacity but recently this capacity has been increased by welding an 8-inch plate around the top of each body. Cars now hold about 5½ tons of run-of-mine ore. Cars are equipped with spring-mounted automatic couplers. The trucks are equipped with 14-inch roller-bearing wheels and 4-wheel brakes.

Main-line trains are made up of 24 cars when a 15-ton trolley locomotive is used, or about 40 cars when a 30-ton tandem is used.

Two 200-kw. motor-generator sets are used to furnish direct current at 250 volts for trolley operation. Charging stations equipped with cranes and small motor-generator sets transfer and recharge the storage batteries for shuttle cars. The combination locomotives are charged direct from the trolley lines, either while at rest or when running on the trolley.

At the No. 1 shaft station cars are fed by gravity to a rotary dump where the ore is dumped onto an apron feeder. The feeder, which will handle 240 tons an hour, conveys the ore to a single-roll-toothed crusher, which reduces it to 5-inch size. From the crusher the ore drops into a 100-ton pocket, then is drawn into skips holding about 5 tons, which are loaded automatically by a double rotary skip loader 80 feet below the mine level. This loader is operated by the skips as they come into and leave the loading positions. The total depth of No. 1 shaft below the level is 92 feet.

Hoisting is done by a double-drum hoist on the surface. This hoist is geared to a 600-hp. direct-current motor. This motor receives its power from a 500-kw. motor-generator fly-wheel set. Hoist drums are 5 by 9 feet. The steel rope is 1¼ inches in diameter and has a speed of 1,250 feet per minute. The steel head frame at the collar of the shaft is 126 feet high, making skip travel 1,125 feet between the loading point below the mine level and the dump at the head frame. Skips are hung below cages and operate in balance, one skip dumping at the head frame while the other is loading at the pocket. Skips dump into a 1,300-ton steel bin at the surface. The hoisting and dumping cycle is completed in about 1½ minutes.

VENTILATION

The ventilation system at the mine of Potash Co. of America is very similar to that of many coal mines using the room-and-pillar mining system. Air is exhausted from No. 2 shaft by a 5- by 7-foot centrifugal fan on the surface, powered by a 125-hp. motor, which exhausts 150,000 cubic feet of air per minute at a water gage of 3½ inches. Air enters the mine through No. 1 shaft, goes to the principal working places through the main haulage entry of a triple or five-entry system, goes through the working places, then passes to No. 2 shaft through side entries. Details of the ventilation system are shown in figures 3 and 4. The fan at the surface is so equipped that by changing four control doors, No. 2 shaft can be made downcast and No. 1 upca

No explosive gases have been encountered in the mine, but the same precautions are used as are used in a gassy mine. No open lights are allowed underground. As mentioned above, intake air is delivered down No. 1 shaft, then through haulageways, and each mining panel is on an independent air split with the air going in through the haulageway and rooms nearest the wor ing faces, then returning to the side entries and on to No. 2 shaft. Concre overcasts carry the air over the haulageways leading into each panel. Salt stoppings are built in each break-through along entries. Wooden doors contr break-throughs which contain panel tracks (see figs. 3 and 4). Brattices ar placed in break-throughs near the working face so the air is forced to pass along this face.

Small electric blowers with canvas tubing are used to ventilate dead ends, these fans being placed in the main air current so they blow fresh air in advanced rooms and development headings.

DRAINAGE

As mentioned in another section of this report, large amounts of water were encountered in sinking the two shafts. In No. 1 shaft a flow of 350 gallons per minute was found, while in No. 2 shaft the flow was as high as 1,000 gallons per minute. This water came from a 10-foot section in the Rustler dolomite 255 feet below the surface. After the shafts were concreted the flow of water was controlled. At No. 1 shaft the water, which was under a pressure of 84 pounds a square inch, was allowed to flow to a 225,000-gallon sump on the 200-foot level, and then pumped from there to the surface for use in the main plant. At No. 2 shaft the water was pumped directly to the surface.

At present both shafts have been grouted so the water flow has been reduced to only about 15 gallons per minute. The water in No. 1 shaft flows to the large sump as before, then is pumped to the surface. Water in No. 2 shaf has been entirely sealed off. Plant water now is pumped from wells at the Pecos River near Carlsbad and goes to the Potash Co. of America plant through a 22-mile pipeline.

SAFETY MEASURES

A safety engineer, who reports directly to the resident manager, is employed by Potash Co. of America. Safety is stressed ahead of all other ends. Several safety trophies and Joseph A. Holmes Safety Association "Certificate of Honor" awards have been presented to the employees as a result of their safety efforts.

A safety committee is appointed by the employees. This committee makes a monthly inspection of the mine and surface plant in an effort to help reduce any hazards to health and safe operations. This committee works with the safety engineer and makes recommendations to improve working conditions.

The company endeavors to have a man in every department and on every shift who has been trained in first aid and who holds a recognized certificate for first aid from the Federal Bureau of Mines, American Red Cross, or other recognized agency. First-aid materials are available at convenient places in the plant and mine.

WAGE SCALE[8]

Potash Co. of America paid the following wages early in 1947:

Mining Department	Per hour
Miners	$1.475
Undercutter operator	1.475
Mining loading-machine operator	1.475
Shot firer	1.475
Trackman	1.475
Motorman	1.475
Shuttle-car operator	1.475
Station tender	1.405
Driller	1.385
Bratticeman	1.365
Undercutter operator's helper	1.365
Mining loading-machine operator's helper	1.365
Pump and powderman	1.365
Timberman	1.365
Nipper	1.275
Track helper	1.275
Toplander	1.265
Mine sampler	1.225
Laborer	1.195
Station helper	1.195
Mechanical, etc. Department	
Mechanics, Class A	1.475
Welders, Class A	1.475
Pipefitters, Class A	1.475
Blacksmiths, Class A	1.475
Layout man, Class A	1.475
Diesel mechanics, Class A	1.475
Carpenters, Class A	1.475
Painters, Class A	1.475
Power house operators	1.475
Mechanics, Class B	1.405
Welders, Class B	1.405
Pipefitters, Class B	1.405
Carpenters, Class B	1.405
Painters, Class B	1.405
Blacksmiths, Class B	1.405
Caterpillar & Bulldozer operator	1.405
Mechanic's helpers, Class A	1.275

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[8] Wage scale taken from agreement between Potash Co. of America and International Union of Mine, Mill & Smelter Workers, effective June 1, 1946.

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Mechanical, etc. Department (Continued)	Per hour
Diesel mechanic's helpers, Class A	$1.275
Painter's helpers, Class A	1.275
Blacksmith's helpers, Class A	1.275
Pipefitter's helpers, Class A	1.275
Mechanic's helpers, Class B	1.225
Carpenter's helpers, Class B	1.225
Painter's helpers, Class B	1.225
Truck drivers	1.225
Pipefitter's helpers, Class B	1.225
Cement finishers and gunite machine operators	1.195
Jack-hammer operators	1.195
Diesel oilers	1.175
Pipefitter laborers	1.025
Mechanic laborers	1.025
Painter's helpers, Class B	1.025
Common laborers	1.025
Miscellaneous	
Hoistman	1.595
Steam fireman	1.345
Water-plant operator	1.245
Laboratory	
Samplers	1.175
Clean-up - Departmental	1.065
Clean-up - Transient	1.025
Supply Warehouse	
Helper, Class A	1.225
Helper, Class B	1.095

In addition to the base hourly wage rates as set forth in the wage scale, the company paid the following for employees working on shifts other than day shift:

For employees working on the second shift, usually from 3 p.m. to 11 p.m., 4 cents additional per hour.

For employees working on the third shift, usually from 11 p.m. to 7 a.m., 8 cents additional per hour.

Potash Co. of America has maintained a far-sighted policy in connection with employee-employer relations ever since it began work in the Carlsbad district.

A large majority of the employees live in Carlsbad and travel to and from work in busses or in their own cars. Houses have been built at the plant for a limited number of key men (see fig. 8). These dwellings are modern in every respect, with gas for heat and cooking and electricity for lighting and general household use. A modern building to house unmarried staff members and a mess hall and commissary also are provided at the plant.

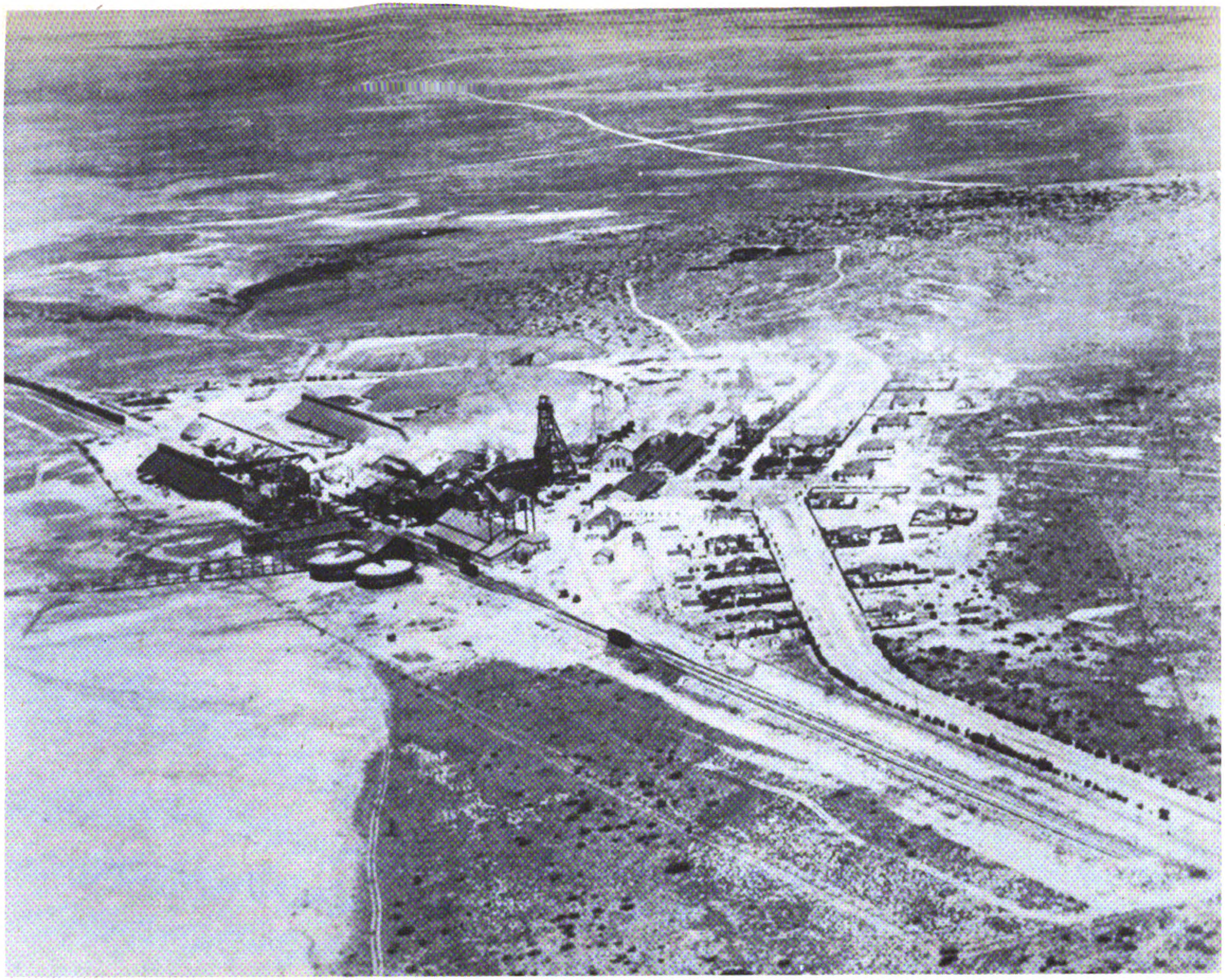

Figure 8. - Aerial view of Potash Co. of America plant.

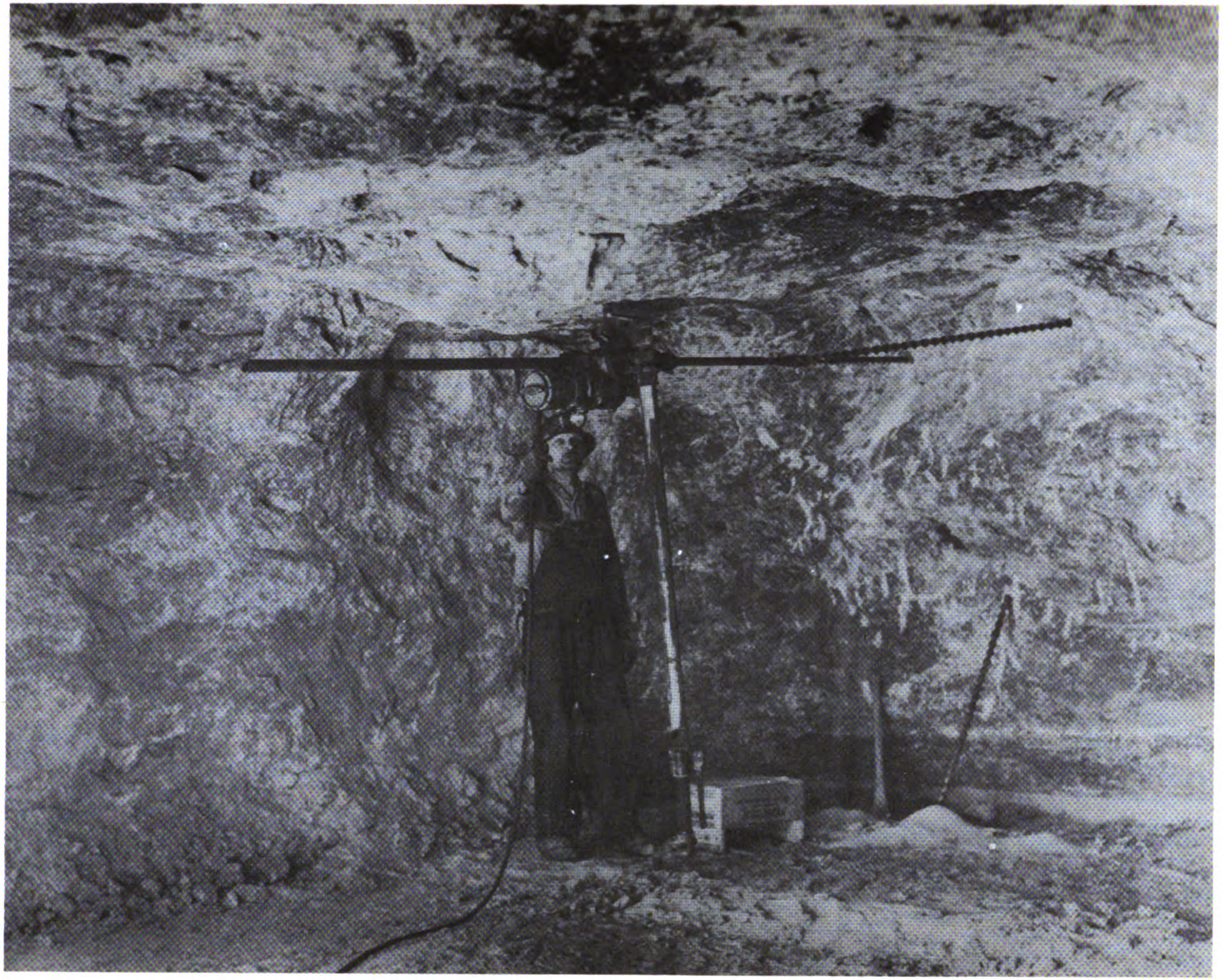

Figure 9. - Miner drilling face with electric drill, using auger steel.

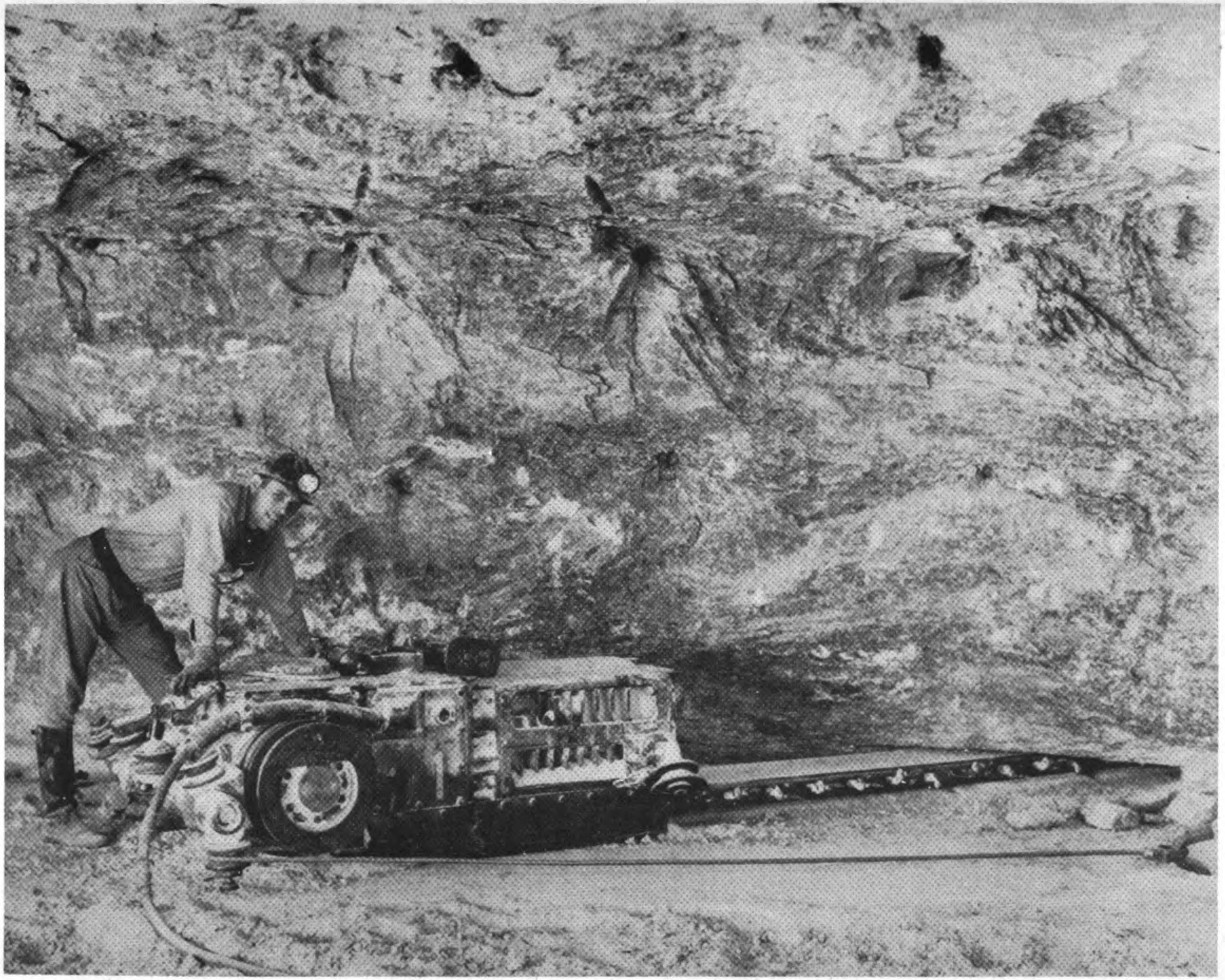

Figure 10. - Shortwall undercutting machine starting to undercut face.

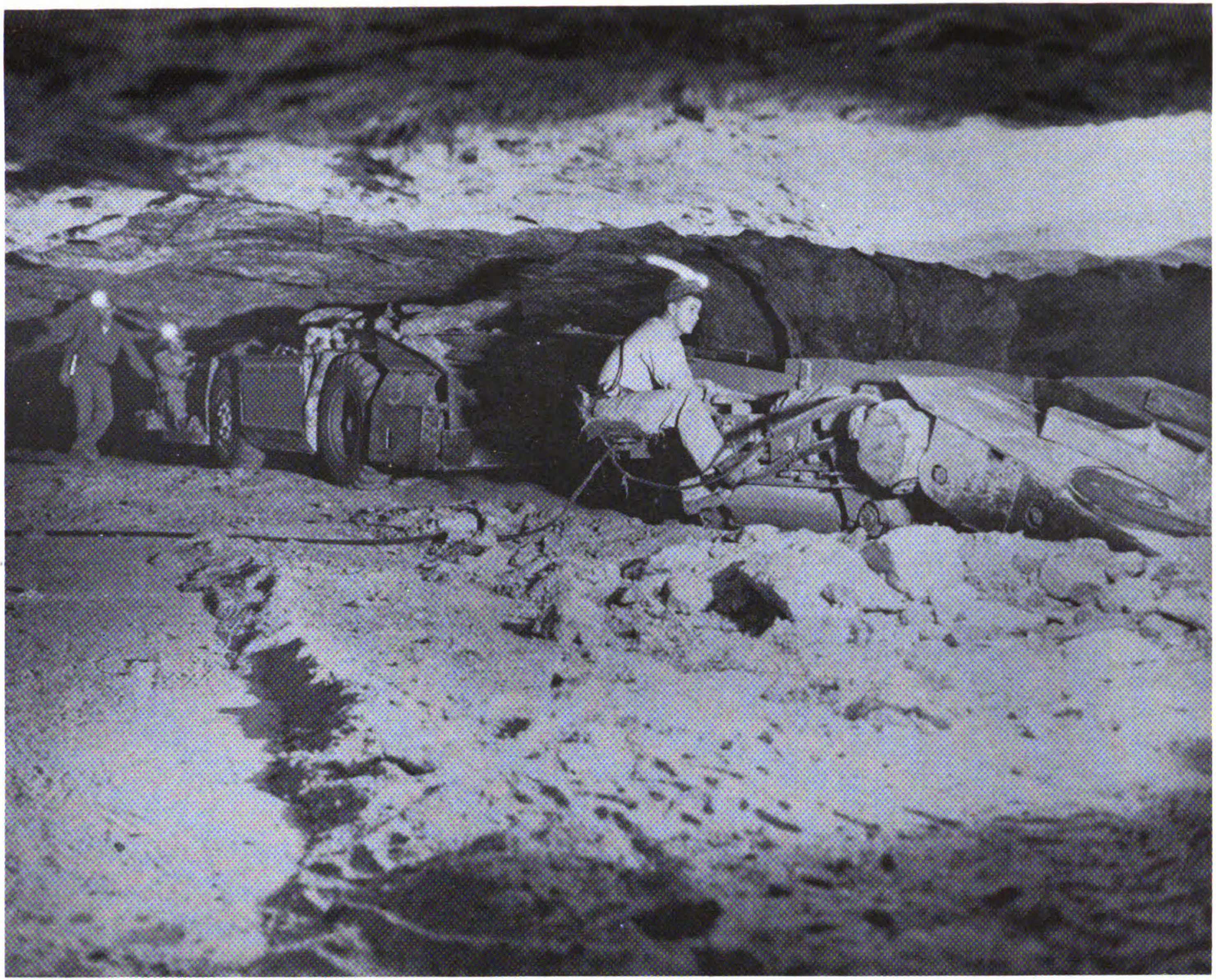

Figure 11. - Trackless loading machine loading into battery-powered shuttle car.

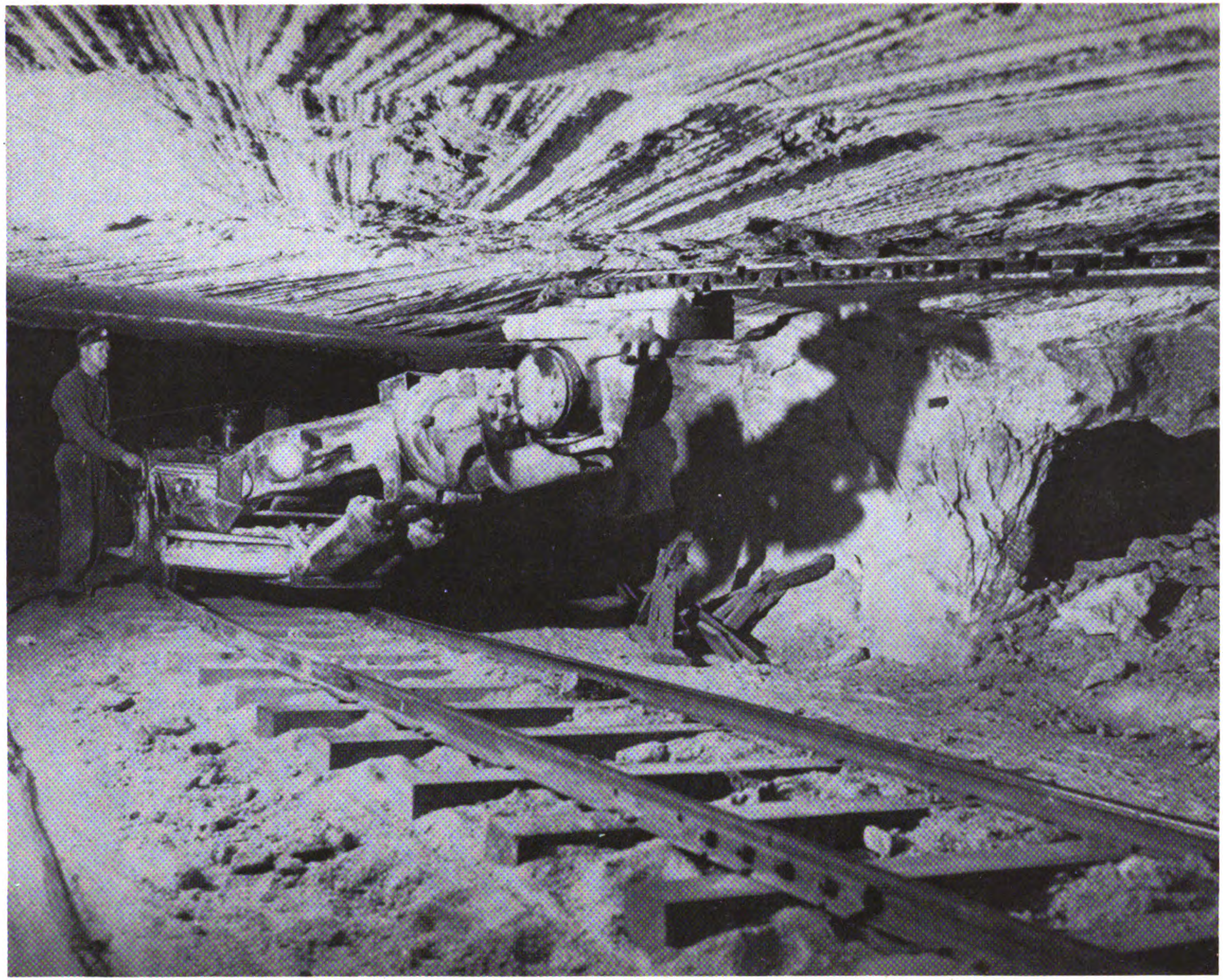

Figure 12. - Universal-type track-mounted undercutting machine "brushing" roof of entry.

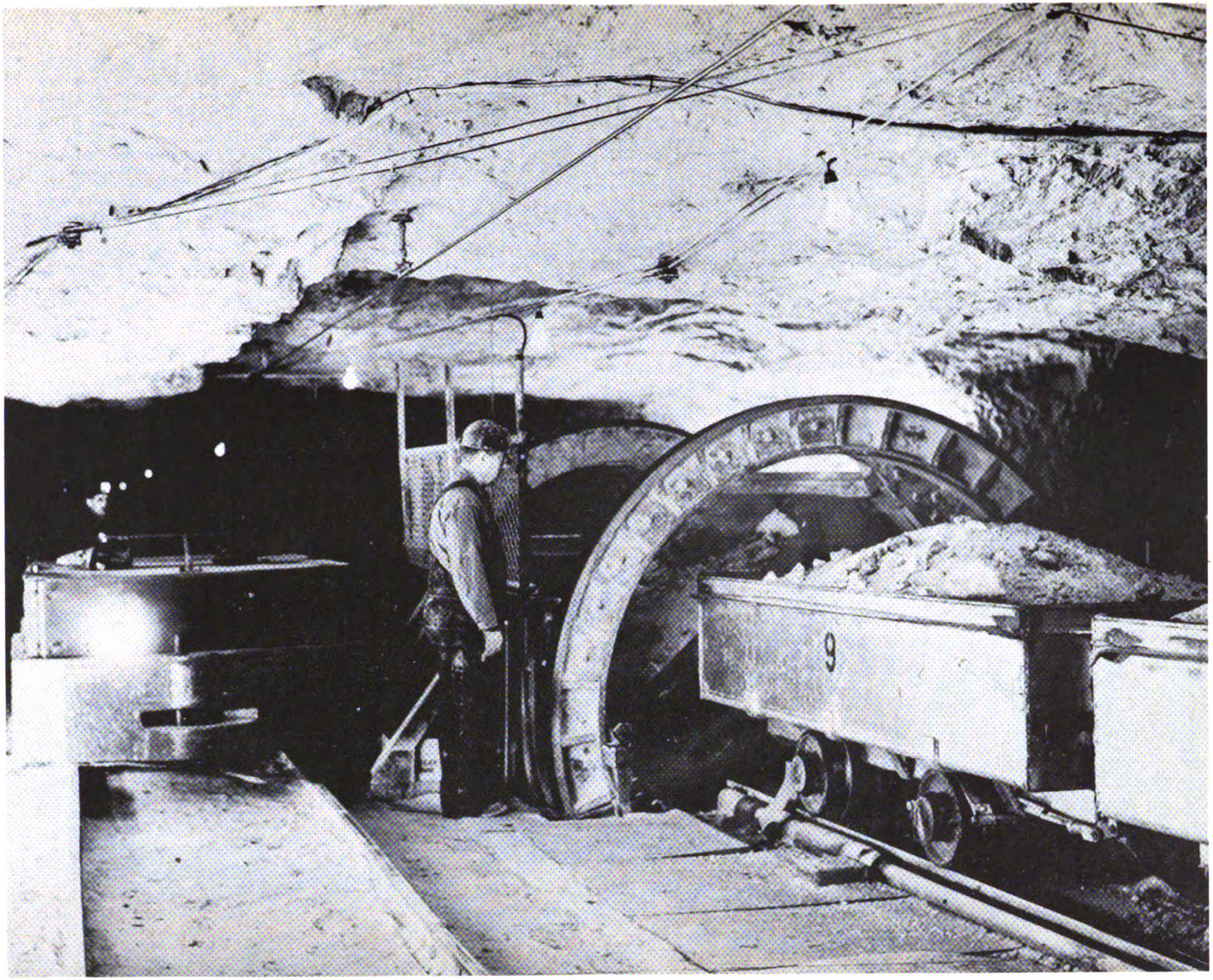

Figure 13. - Rotary dump at No. 1 shaft.

Several years ago it was found that more than half the employees had no life insurance, so the company started a group insurance plan in order to insure every man on the pay roll. Medical and hospitalization plans also are carried out by the company, and a retirement plan is in force for both hourly paid and salaried employees.

Vacations with pay also are granted employees. Employees, other than those on a monthly basis, are given a 1-week vacation with pay if they have worked at least 1 year for the company; if they have worked for 2 years or more they are given 2 weeks. Salaried employers or employees on a monthly basis receive 2 weeks vacation a year.

Sick leave also is allowed employees who have worked for the company for at least 1 year and have 30 days continuous employment. This employee is granted 5 days sick leave with pay. The leave may be taken annually or may be cumulative, although not more than 15 days with pay will be given in any single year.

Sanitary change rooms are maintained at the plant for employees; these rooms contain lockers, showers, and toilet facilities. An outside swimming pool also is provided for employees where they may swim after working hours.

ORGANIZATION

The company organization at the mine consists of a president who directs all operations of the company; a resident manager and an assistant resident manager who direct operations at the plant and mine near Carlsbad; three consulting engineers who advise the operating officials, one of these consultants being in charge of all outside mine examination work; a safety engineer who reports directly to the resident manager; a mine superintendent who has charge of all mine operations; a general mine foreman; several face bosses, each having charge of a certain section of the mine; and several shift bosses who have charge of each shift. Miners and other underground laborers work directly under the direction of the face and shift bosses.

A large, modern, air-cooled office building at the plant houses all officials, as well as clerks, stenographers, etc.

A complete laboratory in charge of a chief chemist also is located near the mine shaft, where research as well as routine chemical and analytical work are done.

Due to the somewhat isolated position of the plant, a large machine shop, which is equipped to handle all major mechanical and electrical repairs, is on the property. Electrical and mechanical repair shops also are provided underground, these shops handling all but major repairs to mining equipment. These operations are under the supervision of a master mechanic.

Figures 9 to 13 picture mining operations.

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Pres. U.S. gov't.